

REPORT DOCUMENTATION PAGE			Form Approved OMB NO. 0704-0188		
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1. REPORT DATE (DD-MM-YYYY) 12-04-2013		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 30-Sep-2010 - 29-Sep-2012	
4. TITLE AND SUBTITLE Terrain Analysis Research Needs to Support Test and Evaluation at YPG: Workshop Report			5a. CONTRACT NUMBER W911NF-10-1-0203		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 611102		
6. AUTHORS Eric McDonald, Rina Schumer, Markus Berli, Heather Green			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Desert Research Institute - Las Vegas Board of Regents, Nevada System of Higher Education, DRI 2215 Raggio Parkway Reno, NV 89512 -			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSOR/MONITOR'S ACRONYM(S) ARO		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) 58171-EV.1		
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT The Workshop included attendance and discussions by about twenty-five YPG personnel including Test Officers (personnel responsible for conducting and coordinating test operations at YPG), YPG Test Branch Directors, and range technicians. Other personnel included five DRI staff (representing expertise in hydrology, modeling, geology, civil engineering, soil science), and representatives from the US Military Academy, and Strategic Planning, Test Resource Management Center.					
15. SUBJECT TERMS Workshop, Test and Evaluation, vehicle test courses, terrain characterization, terrain analogs, soils					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Eric McDonald
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 775-673-7302

Report Title

Terrain Analysis Research Needs to Support Test and Evaluation at YPG: Workshop Report

ABSTRACT

The Workshop included attendance and discussions by about twenty-five YPG personnel including Test Officers (personnel responsible for conducting and coordinating test operations at YPG), YPG Test Branch Directors, and range technicians. Other personnel included five DRI staff (representing expertise in hydrology, modeling, geology, civil engineering, soil science), and representatives from the US Military Academy, and Strategic Planning, Test Resource Management Center.

The workshop provided an environment for dynamic and interactive exchange regarding how best to link knowledge of science and engineering aspects of terrestrial terrain characterization with improving the efficiency of test operations. Issues of interest ranged from how to better characterize current test courses (e.g. terrain, soils, analogs for in theater military operations) to how to provide both test officers and products manufacturers (who are the primary YPG customers) with ready access to important environmental data and science to better conduct test operations.

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(a) Papers published in peer-reviewed journals (N/A for none)

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TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

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Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

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Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

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TOTAL:

Number of Manuscripts:

Books

Received

Paper

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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FTE Equivalent:

Total Number:

Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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FTE Equivalent:

Total Number:

Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	National Academy Member
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Eric McDonald	0.40	
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Rina Schumer	0.25	
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Markus Berli	0.25	
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Heather Green	0.25	
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FTE Equivalent:	1.15	
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Total Number:	4	
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Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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FTE Equivalent:

Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

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Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale): 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PhDs

NAME

Total Number:

Names of other research staff

NAME

PERCENT SUPPORTED

FTE Equivalent:

Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

See Attachement

Technology Transfer

ARO Final Report:

Supplemental Research In Support of ARO Funded Project: Global Military Operating Environments (GMOE): Grant #. W911NF1010203

Terrain Analysis Research Needs to Support Test and Evaluation at YPG: Workshop Report

Workshop held at YPG Countermine Building: Sept 25-26, 2012

Authors: Eric McDonald, Rina Schumer, Markus Berli, Heather Green

Summary of Workshop:

The Workshop included attendance and discussions by about twenty-five YPG personnel including Test Officers (personnel responsible for conducting and coordinating test operations at YPG), YPG Test Branch Directors, and range technicians. Other personnel included five DRI staff (representing expertise in hydrology, modeling, geology, civil engineering, soil science), and representatives from the US Military Academy, and Strategic Planning, Test Resource Management Center.

The workshop provided an environment for dynamic and interactive exchange regarding how best to link knowledge of science and engineering aspects of terrestrial terrain characterization with improving the efficiency of test operations. Issues of interest ranged from how to better characterize current test courses (e.g. terrain, soils, analogs for in theater military operations) to how to provide both test officers and products manufacturers (who are the primary YPG customers) with ready access to important environmental data and science to better conduct test operations.

Scope of Workshop and Agenda:

The main objective of this workshop was to open a dialog among YPG, DRI, and interested Army and DoD personnel focused on linking environmental and terrain science (includes science and engineering related to soil, geology, hydrology, remote sensing, and numerical modeling) with current and future test and evaluation activities at YPG. This activity supports COL Young's (YPG Commander) concept of the "science of test" where academic knowledge of the natural

environmental conditions, both locally and globally, can be utilized to increase the effectiveness of both test and evaluation strategies and product development.

The workshop was held in an informal manner and designed to facilitate open discussion among all participants. Discussions held on Tuesday September 25 were focused on issues related to automotive testing, especially in regards to vehicle durability, mobility, and dust test courses. Discussions held on Wednesday September 26 were focused on issues related to the general testing of sensors and robotics. An overall summary of the workshop and a brief discussion of the major topics identified are presented below.

Summary of Important Topics and Issues

1. Test Result Anomalies: Test failure and anomalies in system testing are common but important details (especially location and environmental setting) are usually not recorded. Discussions identified the need to document all anomalies in order to determine how environmental conditions may be impacting test operations and results. For example, recognition of a common geographic setting associated with sites that have repeatable test anomalies may help identify a specific type of environmental impact on testing of military equipment. (e.g. soil conditions, test course geometry, etc.) Specific points include:
 - Need to record in a common database specific metadata (location, test type, time, etc.) that can be subsequently analyzed to detect patterns of failure
 - Need to document test result outliers (may provide information on environmental impacts to equipment)
 - Need to determine how failures in theater compare to those on test courses
 - Need to determine if failures are similar between test courses and between specific proving grounds
2. Test Center Analogs as Global Military Environments: A common concern was the need for better characterization of YPG managed test centers (Cold Region, Tropic, Desert) and test facilities (e.g. mobility courses, test ranges) to determine if test course and test range conditions represent actual conditions commonly found in theater. Specific needs include:
 - Development of a matrix to compare different test courses across different locations at the terrain level
 - Division of test courses into sections that relate to certain parts of the world (for example, mile x-y relates to central Egypt, Syria, etc.)
 - Comparison of test areas to actual or specific areas in theater

- Exploration of methods to integrate or visualize test course data (for example, application of 3-D imagery of test course terrain attributes to develop appropriate test tracks or test scenarios)
- Updating of the NATO Reference Mobility Model II with more accurate parameters for representing the arid soils and terrain at YPG

3. Improved characterization of test courses and ranges: Test courses require better methods of characterization to develop improved test strategies and to correlate with the natural environmental settings of areas of geopolitical interest. Overall, the need to incorporate new engineering and science-based methods and techniques for characterization of terrain conditions and test course parameters needs to be fulfilled. For example, new advances in the application of LIDAR (Light Detection And Ranging or Laser Imaging Detection And Ranging) to develop detailed DEM (digital elevation models) of test course and associated terrain can be used to develop a comprehensive list of terrain attributes including measures of terrain roughness, average slope angles, aspect, etc. Specific tasks include:

- Develop a list of basic test course attributes that need to be characterized (roughness, profile, soil texture according to USCS, etc.)
- Develop metrics that can be used on all courses and at all proving grounds
- Develop a system that indicates which test course and site would work best for x feature product managers are testing for (we need to be able to better compare testing grounds for certain needs)
- Determine which soil classification system is best for testing purposes (e.g., the USCS or USDA method)
- Apply new methods to characterize terrain roughness
- Develop soil metrics that correlate to surface roughness
- Develop a method to merge LIDAR data with sub-cm profilometry data commonly collected by vehicle mounted profilometers (e.g., the 5 laser based system used at YPG) used to profile course roughness, grade, time-related changes, etc.)
- Increase communication between test community and scientists/engineers who provide terrain characterization so that test operators and product manufacturers better understand how various terrain conditions may impact both test operations and equipment performance
- Develop a protocol or method where soil or test course settings can be queried to determine potential challenging or variable conditions that may occur during certain weather or seasonal conditions

- Increase characterization of key soil properties that control the dielectric properties or permittivity of soil (this information is required to better test equipment and sensors that rely on electromagnetic propagation (e.g., RF, thermal, and GPR methods))

4. Future sustainability of test courses and ranges: Concerns were raised over the future viability and effectiveness of many of the vehicle mobility, durability, and dust test courses. Many of the courses were originally developed in the 1950's. Long term and frequent use has resulted in noticeable changes to some of the courses. Specific issues discussed include:
 - The need to determine options for restoration of test courses at YPG
 - The need to develop procedures to identify land to earmark for developing new replacement test courses

5. Development of 'washboards' on test courses: The development of washboards on frequently used test courses was discussed because this road condition may develop during and between tests, resulting in unwanted temporal variations in test conditions. Specific questions identified include:
 - What are the processes that cause washboards (high vs. low frequency roughness)?
 - What are the maximum levels of washboards you see in real world?
 - Does the development and size of washboards depend on soil type?
 - Can washboard information (size, spacing, etc.) be used as input for fatigue analysis on vehicle parts?